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Outcomes in Heart Failure Patients After Major Noncardiac Surgery

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OBJECTIVES The purpose of this study was to evaluate mortality and readmission rates of heart failure (HF) patients after major noncardiac surgery.

BACKGROUND There is a lack of generalizable outcome data on HF patients undergoing major noncardiac surgery because previous studies have been limited to a few academic centers or have not focused on this group of patients.

METHODS Using the 1997 to 1998 Standard Analytic File 5% Sample of Medicare beneficiaries, we identified patients with HF who underwent major noncardiac surgery. A multivariable logistic regression model was used to provide adjusted mortality and readmission rates in patients after noncardiac surgery. Patients with coronary artery disease (CAD) and all other remaining patients (Control) who had similar surgery served as reference groups.

RESULTS Of 23,340 HF patients and 28,710 CAD patients, 1,532 (6.56%) HF patients and 1,757 (6.12%) CAD patients underwent major noncardiac surgery. There were 44,512 patients in the Control group with major noncardiac surgery. After accounting for demographic characteristics, type of surgery, and comorbid conditions, the risk-adjusted operative mortality (death before discharge or within 30 days of surgery) was HF 11.7%, CAD 6.6%, and Control 6.2% (HF vs. CAD, $p < 0.001$; CAD vs. Control, $p = 0.518$). The risk-adjusted 30-day readmission rate was HF 20.0%, CAD 14.2%, and Control 11.0% ($p < 0.001$).

CONCLUSIONS In patients 65 years of age and older, HF patients undergoing major noncardiac surgery suffer substantial morbidity and mortality despite advances in perioperative care, whereas patients with CAD without HF have similar mortality compared with a more general population. (J Am Coll Cardiol 2004;44:1446–53) © 2004 by the American College of Cardiology Foundation

Over the last 25 years, there has been steady improvement in the care of patients undergoing major noncardiac surgery. However, changes in the epidemiology of patients undergoing surgery may make future care more complicated. Progress in the treatment of chronic diseases such as hypertension, diabetes, and coronary artery disease (CAD) and the ageing population are increasing the prevalence of heart failure (HF) (1,2). Already, there are an estimated 550,000 new cases of HF each year and an estimated prevalence of five million patients with over 75% age 65 years and older (3–5). In addition, the elderly is an important group undergoing noncardiac surgery at increasing rates (6). Therefore, examination of outcomes in these understudied, yet higher risk groups will help clarify areas needed for improvement.

Coupled to the growing HF and elderly populations is the dramatic increase in the number of surgical procedures. Since 1990, the number of procedures has increased from 27 million to nearly 40 million. There are over 10 million major noncardiac surgeries performed each year, with the largest group in patients age 65 years and over (6).

Previous studies emphasize ischemic heart disease as the most important risk for perioperative complications, but HF has been equally important (7–10). Furthermore, little is known about how HF patients fare with perioperative recommendations. In fact, there is little to guide clinicians on how to manage patients with HF through the perioperative period (11). The most widespread recommendation of using beta-blockers in patients at risk for perioperative complications has only been studied in 30 patients in clinical studies (11–15). Thus, although numerous advances in perioperative care have focused on the management of coronary disease, it is unknown how this modifies perioperative risk among HF patients.

Finally, previous studies evaluating perioperative risk of complications during noncardiac surgery have several limitations. In general, studies evaluating perioperative risk have been limited to only one or a few academic centers, so it is difficult to know what the rate of perioperative complications is in the general population or routine practice. Most studies were also limited to inpatient mortality and failed to examine mortality in the early post-discharge period. In addition, readmission rates have not been routinely examined (7,9,10,16). Therefore, we sought to evaluate mortality and readmission rates of HF patients after major noncardiac surgery using a database from Medicare that provides a national representation of elderly patients undergoing major noncardiac surgery.

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Abbreviations and Acronyms

CAD	= coronary artery disease
HF	= heart failure
ICD-9	= International Classification of Diseases-9th Revision
SNF	= skilled nursing facility

METHODS

Data source. The primary data source was the Medicare claims files provided by the Center for Medicare and Medicaid Services from 1997 to 1998. The standard analytic file is a nationally random sample of 5% of the Medicare beneficiaries and includes all in-patient hospitalizations that are billed to Medicare. The files contain demographic and limited clinical information such as age, gender, race, discharge status including death, up to 10 discharge diagnoses, and 6 procedures identified by International Classification of Diseases, 9th Revision (ICD-9) and Current Procedural Terminology codes (17,18). Mortality data came from the Medicare records and date-of-death files. All Medicare beneficiaries in the fee-for-service system age 65 years or older were eligible for the study.

Patient populations. To avoid classifying patients who suffered HF or CAD as complications of surgery who did not have such disease before the procedure, we first identified all patients with HF or CAD from a non-surgical admission who were discharged alive. Once identified, these cohorts were followed for subsequent hospitalization for noncardiac surgery.

Our study population consisted of three separate cohorts consisting of patients with a history of HF, a history of CAD, and the remaining patients who had major noncardiac surgery (Control). For the HF cohort, we identified patients who were admitted with a primary diagnosis of HF based on ICD-9 codes (402.01, 402.11, 402.91, 402.92, 425.0, 428.x) (19). Patients who survived to discharge and subsequently had a major noncardiac surgery in the following year were included into our HF cohort. The HF cohort was further stratified into two groups according to secondary diagnosis of CAD (ICD-9 codes 410.x, 411.x, 412, 413, 414). We identified two additional groups for comparisons: CAD—patients who had CAD but no HF in the previous year; and Control—all remaining patients who underwent major noncardiac surgery without hospitalization for HF or CAD during the previous year.

Major noncardiac surgeries were identified using appropriate Current Procedural Terminology-4th Revision codes classified into five groups (Vascular, Abdominal, Thoracic, Orthopedic, and Other) and as elective, urgent, or emergent (18). Only patients with a primary Diagnosis Related Group related to the primary procedure code of a major noncardiac surgery were included into the cohorts. Minor procedures such as breast surgery, endoscopies, and superficial procedures were excluded. To avoid counting patients more than once, only the first episode of noncardiac surgery was included in the study.

Data analysis. The primary outcome of the study was operative mortality, defined as death before hospital discharge or within 30 days after the procedure. Other outcomes analyzed were mortality 30 days after discharge, readmission within 30 days of surgery for any reason, length of stay, and days in the intensive care unit.

Patients were characterized according to demographic characteristics and comorbid illness as described by the Charlson index (19). We also considered other variables such as teaching status of the hospital, admissions to and from skilled nursing facilities (SNF), and readmissions between index identification and surgery. Categorical variables were compared between groups using the Pearson chi-square test, and continuous variables were compared using the non-parametric Kruskal-Wallis test.

Logistic regression models were developed to examine the relationship of major noncardiac surgery mortality and

Table 1. Baseline Demographics

	HF (n = 1,532)	CAD (n = 1,757)	Control (n = 44,512)	p Value
Mean age (yrs ± SD)	78.7 ± 7.6	76.0 ± 6.5	77.4 ± 7.5	<0.001
Non-white (%)	15.6	9.2	9.9	<0.001
Male (%)	39.8	55.9	41.4	<0.001
Time (days) from index admission to surgery (mean ± SD)	151.4 ± 109.2	148.2 ± 107.4	n/a	0.441
Charlson index (mean ± SD)	1.67 ± 1.91	1.64 ± 1.95	1.51 ± 2.17	<0.001
ESRD (%)	11.5	4.5	1.9	<0.001
Ischemic heart disease (%)	45.2	100	20.8	<0.0001
Admitted to a teaching hospital (%)	17.5	18.3	15.5	<0.001
Admitted from a SNF (%)	2.7	1.2	1.3	<0.001
Discharged to a SNF (%)	29.8	17.9	26.9	<0.001
Surgery admission type				<0.001
Elective	32.0	50.0	48.6	
Urgent	26.0	21.7	21.3	
Emergent	41.7	28.1	30.7	

CAD = coronary artery disease; ESRD = end-stage renal disease; HF = heart failure; n/a = not applicable; SNF = skilled nursing facility.

Table 2. Frequency of Procedure Type by Cohort

	HF (n = 1,532)	CAD (n = 1,757)	Control (n = 44,512)	p Value
Abdominal (%)	22.7	23.1	23.5	0.702
Orthopedic (%)	26.1	22.5	45.4	<0.001
Thoracic (%)	8.2	9.9	6.6	<0.001
Vascular (%)	28.7	36.3	16.7	<0.001
Other (%)	14.4	8.3	7.8	<0.001

Abbreviations as in Table 1.

having a history of HF or CAD. Variables were selected for the final model by strength of association with $p < 0.05$.

Kaplan-Meier curves were generated to evaluate mortality 30 days after admission based on urgency of the procedure. The log-rank test was used to compare results.

RESULTS

In the year after the index HF hospitalization, 1,532 (6.6%) of 23,340 identified HF patients had a major noncardiac surgery in a mean time of 151 days after the index hospitalization. Ischemic heart disease was indicated as a secondary diagnosis in 45.2% of HF patients. During the year after the index CAD hospitalization, 1,757 (6.1%) of 28,710 identified CAD patients had a major noncardiac surgery in a mean time after the index hospitalization of 148 days. Of those in the HF cohort, 48.0% had no readmissions between index admission and surgery, whereas 28.7% had one readmission and 13.3% had two readmissions. Within the CAD cohort, 59.8% had no readmissions before surgery, whereas 22.5% had one readmission and 10.4% had two readmissions before surgery. The primary diagnosis to qualify for the HF cohort was 428.0 (HF) in more than 90% of the patients. The primary diagnosis to qualify for the CAD cohort was chronic ischemic heart disease (414.01) in 50% of the patients and myocardial infarction (410.x) in 28% of the patients. Patients classified with these two diagnoses accounted for the majority of the subsequent operative mortality with 42.4% of the operative deaths coded as chronic ischemic disease (414.x) and 47.5% of the deaths coded as myocardial infarction (410.x) on entry into the CAD cohort. The other diagnostic codes for intermediate coronary syndrome (411.x), old infarction (412.x), and angina (413.x) accounted for the remaining operative mortality. Over the study period, 44,512 patients remained who had a major noncardiac surgery but who did not have HF or CAD.

Patients with HF were older and more likely to be female and nonwhite compared with the CAD and control cohorts (Table 1). The time to surgery was similar in the HF and CAD cohorts. The HF cohort had a higher Charlson index than the CAD and the control cohorts, indicating higher prevalence of comorbid conditions. There was also a higher rate of end-stage renal disease in the HF cohort than the other groups. Admissions to a teaching hospital for surgery occurred more often for CAD patients than patients in the HF or control cohort. Very few patients were admitted for surgery from a SNF, but a much larger number were discharged to a SNF. The HF patients were more likely to be discharged to a SNF compared with the CAD and control patients. The HF patients also had a higher rate of emergent or urgent surgeries than the CAD and control patients.

The distribution of procedure types is shown in Table 2. The control cohort had mostly orthopedic procedures, whereas the HF and CAD cohorts underwent vascular procedures more often. Procedures classified as "other" consisted of extremity amputations, prostate surgeries, neurosurgeries, gynecologic surgeries, and nonvascular head and neck procedures. Table 3 shows the outcomes by procedure type.

For the logistic regression model, significant variables included age, gender, Charlson index, procedure type, admission from a SNF, and urgency of surgery (Table 4). Age was transformed into two variables, above and below 75 years, to satisfy model assumptions. Race and teaching status of the hospital were also evaluated but were not included in the final model owing to lack of statistical significance.

Outcomes. The primary outcome of operative mortality (death before discharge or within 30 days of the procedure) was 11.7% after risk adjustment in the HF cohort compared with 6.6% in the CAD cohort and 6.2% in the control cohort (HF vs. CAD, $p < 0.001$; CAD vs. Control, $p = 0.518$). Risk-adjusted inpatient mortality during surgery admission was 7.9% in the HF cohort, whereas the CAD and control cohorts had lower mortality of 4.6% and 4.1%, respectively (HF vs. CAD, $p < 0.001$; CAD vs. Control, $p = 0.328$). Mortality 30 days after discharge also showed similar results, 6.5% in the HF cohort and 3.3% and 3.2%, respectively for the CAD and the control group (HF vs. CAD, $p < 0.001$; CAD vs. Control, $p = 0.904$) (Table 5).

The HF cohort was stratified into two groups of patients with CAD criteria as a secondary diagnosis and without. However, there was no difference between these two strata in the final model, so all adjusted outcomes are reported grouped together within the HF cohort ($p = 0.304$). Observed 30-day mortality in HF patients without CAD was similar or higher than HF patients with CAD. Heart failure patients with and without CAD had a two- to four-fold higher mortality rate than the CAD and control groups (Table 6). To ensure that our results were not unduly influenced by end-stage renal disease, these patients were

Table 3. Outcomes by Procedure Type

	Abdominal (n = 11,220)	Orthopedic (n = 21,020)	Thoracic (n = 3,239)	Vascular (n = 8,497)	Other (n = 3,825)	p Value
Primary outcome: operative mortality (95% CI)	10.1% (9.5%–10.6%)	3.8% (3.5%–4.1%)	12.0% (10.9%–13.1%)	5.7% (5.2%–6.1%)	7.3% (6.4%–8.1%)	<0.001
Mortality during surgery admission (95% CI)	8.0% (7.5%–8.5%)	1.8% (1.6%–1.9%)	8.2% (7.2%–9.2%)	4.3% (3.9%–4.8%)	4.2% (3.5%–4.8%)	<0.001
30-day mortality in discharged patients (95% CI)	4.2% (3.8%–4.6%)	2.9% (2.6%–3.1%)	7.1% (6.1%–8.0%)	2.1% (1.8%–2.4%)	4.7% (4.0%–5.3%)	<0.001
Readmission rate within 30 days (95% CI)	12.3% (11.7%–12.9%)	8.8% (8.4%–9.2%)	15.7% (14.4–16.9%)	14.1% (13.3%–14.9%)	14.4% (13.3%–15.5%)	<0.001
Mean length of stay (days ± SD)	11.2 ± 10.6	8.3 ± 7.9	10.9 ± 9.6	7.2 ± 9.6	8.9 ± 23.7	<0.001
ICU stay (%)	39.8	9.3	46.5	65.7	12.6	<0.001
Discharged to SNF (%)	16.2	42.9	11.3	9.2	20.4	<0.001

CI = confidence interval; ICU = intensive care unit; SNF = skilled nursing facility.

Table 4. Odds Ratio for 30-Day Mortality

Effect	Odds Ratio	95% Wald Confidence	Limits
HF vs. control	2.187	1.880	2.545
CAD vs. control	1.078	0.884	1.315
HF vs. CAD	2.029	1.592	2.585
1-yr increase in age (≤75 yrs)	1.025	1.007	1.043
1-yr increase in age (≥75 yrs)	1.072	1.065	1.080
Male vs. female	1.290	1.190	1.398
1-U increase in Charlson index	1.117	1.101	1.134
Thoracic vs. orthopedic	3.498	3.028	4.041
Abdominal vs. orthopedic	2.525	2.278	2.799
Other vs. orthopedic	2.066	1.775	2.405
Vascular vs. orthopedic	2.201	1.937	2.500
Emergent vs. elective	4.002	3.612	4.435
Urgent vs. elective	2.635	2.355	2.948
Admitted from SNF	1.895	1.509	2.378

Abbreviations as in Table 1.

excluded and the models yielded similar results for all outcomes including operative mortality and 30-day readmission rate.

During the surgery admission, the length of hospital stay and intensive care unit stay was longer in HF patients. All three groups were readmitted within an average of approximately 13 days. The HF patients were admitted 20.0% of the time compared with 14.2% of the CAD patients and 11.0% of the control patients (HF vs. CAD, $p < 0.001$; CAD vs. Control, $p < 0.001$). The most common primary diagnosis for readmission in all groups related to the initial surgery. However, the second most common primary diagnosis in the HF cohort was HF (428.0).

Kaplan-Meier curves also demonstrate the higher mortality rate of HF patients after surgery regardless of procedure urgency (Fig. 1). The CAD and the control cohorts had a similar mortality throughout the study period.

Background rates of mortality for HF patients without surgery who were admitted for HF were 5.4% at 30 days after discharge from the index admission, 22.4% at six months and 33.4% at one year. The CAD patients who did not have surgery but were discharged alive from the index admission had a 30-day mortality of 2.2%, 6-month mortality of 7.3%, and 1-year mortality of 10.7%.

DISCUSSION

In this study, the largest description of HF patients undergoing major noncardiac surgery, HF patients had a twofold higher mortality and readmission rate than those with coronary disease or the control population. The markedly higher mortality was apparent across all types of surgeries with a two- to four-fold increase in mortality for HF patients compared with all others. This is especially important when considering that more than 75% of all HF patients are older than 65 and have the highest incidence of major noncardiac surgeries (6,20). Heart failure patients have higher mortality rates over time compared with other patients, but the background mortality rate of HF patients

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Table 5. Outcomes

	HF (n = 1,532)	CAD (n = 1,757)	Control (n = 44,512)	p Value*
Primary outcome: 30-day mortality (95% CI)				
Observed (%)	15.4 (13.6–17.3)	6.6 (5.5–7.8)	6.1 (5.9–6.3)	
Risk-adjusted (%)	11.7 (10.2–13.1)	6.6 (5.4–7.8)	6.2 (6.0–6.4)	<0.001
Mortality during surgery admission (95% CI)				
Observed (%)	10.7 (9.2–12.0)	5.0 (4.0–6.1)	4.1 (3.9–4.2)	
Risk-adjusted (%)	7.9 (6.8–9.0)	4.6 (3.6–5.5)	4.1 (3.9–4.3)	<0.001
30-day mortality in discharged patients (95% CI)				
Observed (%)	8.4 (6.9–9.9)	2.9 (2.1–3.7)	3.3 (3.1–3.5)	
Risk-adjusted (%)	6.5 (5.4–7.6)	3.3 (2.4–4.3)	3.2 (3.0–3.4)	<0.001
Readmission rate within 30 days (95% CI)				
Observed (%)	23.6 (21.5–25.8)	15.5 (13.8–17.2)	10.9 (10.6–11.2)	
Risk-adjusted (%)	20.0 (18.3–21.8)	14.2 (12.5–15.8)	11.0 (10.7–11.3)	<0.001
Mean length of stay (days ± SD)	11.0 ± 10.6	9.3 ± 10.5	8.9 ± 11.1	
Mean length of ICU stay (days ± SD)	4.9 ± 6.0	4.2 ± 5.2	4.1 ± 5.6	0.015
Patients with an ICU stay (%)	44.7	48.2	28.0	0.053
Mean time to readmission (days ± SD)	13.0 ± 8.5	13.3 ± 8.5	13.2 ± 8.4	0.709

*p value for difference between HF and CAD groups; p value for difference between CAD and control group is >0.05 except for readmission rate (<0.001) and % ICU stay (<0.001).

Abbreviations as in Tables 1 and 3.

after a non-surgical hospitalization was only 5.4%. Interestingly, the diagnosis of coronary disease was less important in HF patients because those with and without coronary disease had similarly poor outcomes. Although the difference in the mortality rates between the CAD and the HF cohorts may be due to other unmeasured clinical factors such as revascularization or beta-blocker use, it is clear that HF patients known to be high risk need great attention.

Previous studies have demonstrated that HF is an important risk factor, but the magnitude may be underappreciated. Heart failure has been either the most significant risk factor for perioperative complication or among the highest in previous studies (7,9,10,16,21,22). Although previous strategies for preoperative risk stratification emphasized the identification of coronary disease, the importance of HF is clear from this study (8,11). In comparison to testing and interventions for coronary disease, which often delay surgery for weeks, early identification and optimization of HF may be done easily in the future with advances in diagnostics and therapies.

The similarity in mortality between CAD patients without HF and the general population supports the notion that these patients do not routinely need additional testing unless required for unstable symptoms or if beta-blocker therapy perioperatively is contraindicated (23). However, our study demonstrates that the presence of HF substantially increases the risk of mortality, which is not a component of suggested algorithms. Therefore, evidence-based strategies are needed for constructing recommendations in professional guidelines to manage HF patients perioperatively.

In comparison to some studies, the overall mortality rate was higher, but compared with other Medicare studies it is similar. In general, earlier studies have been in one or a few academic centers or restricted to the Veterans Administration system (7,9,10,16,24,25). Most studies taking place at one or a few academic centers only report in-patient mortality, which is lower than in our study (10,16). These studies differ from ours largely with respect to the age of the study population, but also because of other patient comorbidities, with previous studies having younger, healthier patients compared with our study. Studies of the Medicare population had similar mortality rates as this study, with 30-day mortality of 7% in a study by Fleisher et al. (26) in vascular surgery and 4% to 20% depending on the procedure in a study by Birkmeyer et al. (27). By using a national sample, our study provides an assessment of outcomes when patients are not necessarily part of a study emphasizing the reduction of perioperative morbidity. Furthermore, this study helps provide important insight into the outcomes of elderly patients who undergo noncardiac surgery in a variety of hospital settings where it is known that there is variation in the quality of care (28,29).

Table 6. Observed 30-Day Mortality by Cohort, Procedure Type, and Heart Failure Stratified by Presence of CAD

	Abdominal (%)	Orthopedic (%)	Thoracic (%)	Vascular (%)	Other (%)
HF with CAD	28.4	20.8	28.1	14.7	20.3
HF without CAD	35.9	18.3	35.5	12.6	30.2
CAD	12.8	5.8	17.6	4.6	12.4
Control	12.9	4.5	16.6	6.5	8.5

Abbreviations as in Table 5.

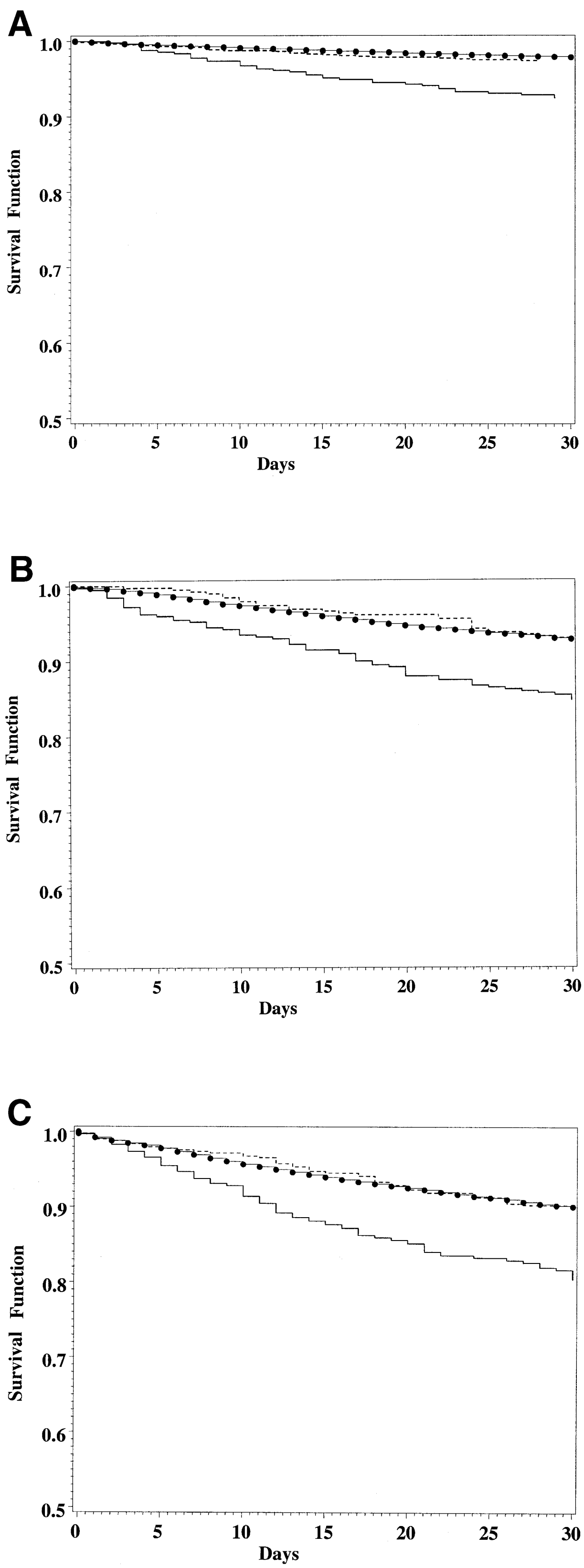

Figure 1. Kaplan-Meier curves of **(A)** survival after elective surgery, **(B)** survival after urgent surgery, and **(C)** survival after emergent surgery. Log-rank test used for comparisons. Heart failure (HF) versus coronary artery disease (CAD)/Control, $p < 0.001$. CAD versus Control, $p =$ NS. **Solid lines** = HF; **dashed lines** = CAD; **lines with filled circles** = Control.

Our study also shows readmission rates are almost twofold higher for HF patients than patients with coronary disease and the control population. Despite having a slightly longer length of stay, there was a 20% readmission rate for any cause. There appears to be an important need for surveillance of patients with a history of HF in the hospital to ensure that discharge is appropriate, plus close follow-up of outpatients to prevent readmissions. A multidisciplinary approach may prevent readmissions, ensure appropriate medication use, and hopefully prevent excess mortality as done currently in some centers for patients admitted with HF exacerbations (30,31).

There are many possible reasons why HF patients fare worse during the perioperative period, with type and urgency of surgery being the most important. Although our study attempted to adjust for mix and risk of surgery type, there may be unmeasured factors related to the type of surgery performed in HF patients that cannot be fully accounted for in this study. Patients with severe HF may undergo procedures to treat complications of HF as their severity of illness increases. In our study, HF patients underwent urgent and emergent surgeries more often than other patients that entailed additional risk compared with elective procedures. Accordingly, our study highlights a need for research in HF patients, especially those undergoing urgent and emergent surgery, to identify those patients at the highest risk and to attempt a therapeutic intervention to reduce the risk. This is possible because, in general, there are few procedures that cannot be delayed for some period in an attempt to stabilize other conditions such as HF. Also, elective surgeries in HF patients may be unduly delayed until absolutely necessary, causing more emergent or urgent procedures to be performed, providing another opportunity for the risk stratification of HF patients who have surgical needs.

Other non-surgical issues may increase the risk of HF patients. There may be a lower use of beta-blockers perioperatively in patients with moderate to severe HF because of hemodynamic concerns that cannot be determined from our data. During the study period, the penetrance of beta-blockers may be lower in HF patients compared with those with coronary disease, but this continues to be a problem despite routine recommendations (32). There may also be a lower use of revascularization procedures in HF patients. However, these factors are unlikely to account for the majority of the mortality difference found in this study. Clinically, it may be difficult for physicians to assess worsening HF symptoms because patients are limited in other ways for which surgery is required. The lack of good physical examination skills and fluid shifts during surgery and the inability to respond to stress may also impact HF patients' surgical outcomes.

Our study raises the question of what transpires perioperatively in HF patients beyond ischemia from underlying coronary disease. Other factors may play a role, because our study shows that HF patients without a history of coronary disease had similar mortality as those with coronary disease. Furthermore, there have not been any significant studies in over a decade specifically characterizing the reasons HF patients do poorly (33,34). Advances over the last decade in the understanding of HF should be applied to new investigations of the pathophysiology of perioperative complications in HF patients beyond the classic supply/demand ischemia hypothesis used for patients with coronary disease (35,36).

Although we cannot characterize the HF population into those with systolic dysfunction and those without, future studies should investigate the differences of these two types of HF undergoing major noncardiac surgery. Previous studies did not evaluate HF with preserved systolic function in the perioperative setting because its importance and characteristics did not become apparent until the last several years (37,38). The elderly have a high prevalence of HF with preserved systolic function that may be important in the perioperative setting because of poor tolerance to volume overload, a common perioperative event. The baseline demographics show a majority of women in the HF cohort, which is consistent with other studies of HF in the elderly. Thus, there are likely many patients with HF and preserved systolic function who are at risk for postoperative complications.

Finally, future studies are also needed to address how to reduce the perioperative risk of cardiac complications in HF patients, including more extensive studies of beta-blockers, statins, and angiotensin-aldosterone antagonism (39). Although the long-term benefit of beta-blockers is established in HF patients, several issues may arise over the short term when attempting to titrate beta-blockers over a few days as opposed to several weeks as normally done in outpatient HF management (40). Heart failure patients who present for urgent or emergent procedures are high risk, and procedures to quickly identify their level of compensation and optimize their HF before undergoing a major surgery need to be identified. Future work should also clarify the role of right catheterization of advanced HF patients in the perioperative setting as there is little evidence for this procedure despite some recommendations (41,42).

Study limitations. While Medicare is the one of the few sources to examine national outcomes in men and women undergoing noncardiac surgery, it is limited in the extent and accuracy of clinical information (43). Previous work has pointed to the limitations of using ICD-9 codes for the development of models for assessing surgical quality, and we cannot assume that all factors accounting for the outcomes have been included in our models (44). This includes the lack of data for medication use such as beta-blockers or other medications used to treat cardiovascular disease. To be identified as HF or CAD, patients had to have a previous hospital admission for entry into those cohorts, respectively. This may increase their risk of postoperative complications, and patients with HF or CAD who did not have a hospital admission during the identification period were not specifically studied. Our study only included patients age 65 years and older, but complications in this group are important, with at least four million major noncardiac surgeries each year as well as the predicted growth in this population (6,45–47). We cannot determine accurately if readmissions were a result of surgical complications or if readmissions were due to non-surgical issues such as HF. Even if there were readmissions for surgical issues, HF patients may have problems related to their disease such as edema, poor healing, malnutrition, electrolyte abnormalities, renal insufficiency, and anemia.

CONCLUSIONS

In patients age 65 years and older, HF patients suffered significant morbidity and mortality after undergoing noncardiac surgery. Patients with coronary disease undergoing major noncardiac surgery had better outcomes than HF patients and similar outcomes to the control cohort. Future research is needed to understand why HF patients do poorly with noncardiac surgery to prevent perioperative complications.

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